

Management of hazardous dental wastes in King County, 1991-2000

Hazardous Waste Management Program
Water and Land Resources Division
Dept. of Natural Resources, King County

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Summary

Mercury spikes in King County's wastewater treatment system ten years ago prompted the county to identify sources of mercury. The dental sector was found to be a "significant and identifiable" source of mercury to the wastewater treatment system (Metro, 1991). In an attempt to reduce mercury discharges, King County began to work with the dental sector in 1994.

Capturing and properly disposing mercury-bearing amalgam waste is relatively straightforward. Sink traps, vacuum pump filters, and in-office wastewater treatment units all filter or otherwise extract amalgam particles from dental wastewater, leaving the wastewater virtually mercury-free. Capturing mercury-bearing wastes from dental offices is one clear method for reducing potential mercury contamination in the environment.

Since the mid-1990's, King County and the local Dental Society have collaborated to obtain a voluntary change in waste collection and disposal practices. The King County Hazardous Waste Program and the Seattle-King County Dental Society provided information to dentists about proper waste management in a wide variety of formats. Environmentally responsible dentists were certified and publicized as 'EnviroStars,' and new options for waste disposal were promoted.

What about results? After five years of aggressive outreach on the part of the SKCDS and King County, results are mixed and not overwhelming. Whereas four years ago there were no pick-up services available for dental hazardous waste, four local companies now offer dental waste pick-up programs. Three Northwest companies now sell wastewater treatment units, and a national mail-away amalgam program advertises in the Seattle area.

Currently, sixty percent of King County dentists properly reclaim fixer waste and forty percent recycle lead foils. A significant percentage collect and hold on to each wastestream, looking for options. With regard to mercury-bearing amalgam wastes, 38 percent collect and reclaim scrap amalgam, 27 percent properly manage chairside trap amalgam, and sludge collected in the vacuum pump is properly disposed by 13% of dentists. Out of the 1000 potential customers for in-office wastewater treatment units, 25 have been sold.

These results raise several issues as the program looks to the future. They include:

- Whether or not new services continue to be available to dentists depends on their use. If no one uses waste management services, they will go away.
- A number of dental offices have invested significant resources to set up proper waste management systems. This creates the issue of a level playing field. How does the dental community view the fact that there are different levels of compliance among dental offices?
- After the proposed rule requiring installation of separation units was set aside in 1995, King County looked to voluntary installation of this equipment. Only 25 offices have done so. Why? What are the barriers and now should they be addressed?

1. Introduction: Dentists and hazardous waste

In Washington State the monitoring of small quantity generators of hazardous waste is delegated to counties. In King County, the Local Hazardous Waste Management Program (LHWMP) works with small quantity generator businesses to help them reduce, properly manage and legally dispose of dangerous wastes. The LHWMP provides information, makes on-site visits, offers financial incentives and promotes 'green businesses.' Because dental wastes are often dangerous wastes due to mercury, silver, lead and flammability, the LHWMP has worked with this professional sector for the past five years.

As with other dangerous wastes, dental wastes that designate as dangerous under state regulations (RCW 173.303) must be reclaimed or managed by licensed transport, service, disposal or recycling facilities (TSDR's). Responsibilities of dental offices, like other small quantity generator businesses, are fairly straightforward: they must designate their waste (determine if it is dangerous waste), and if dangerous waste, store and transport it safely and dispose of it legally. Dangerous waste may not be disposed with infectious waste, go into the landfill, and or be discharged into the sewer, septic system or storm drain.

Dental amalgam waste comes in several forms: scrap amalgam, chairside trap waste and pump filter sludge (collected at the vacuum pump). One question for dentists is whether these wastes designate as dangerous waste under state law. Testing shows that there is variability from sample to sample. Whether or not a sample designates can depend on such variables as whether the office places and removes amalgam fillings (and how often), how long the sample has aged, and how much amalgam is in the sample relative to other material. Tests of eight samples of chairside trap waste found that in three cases the waste designated as dangerous waste (that is, failed the TCLP test for mercury) (LHWMP, 1997). Tests of two samples of scrap amalgam found that both designated as dangerous waste, and one sample of pump filter sludge also designated. Tests of chairside trap waste from four dental offices in 1998 found the same result: some samples designated as dangerous waste and others did not (Peacock, 2000). What this means is that a particular office can't know for sure whether its amalgam waste designates as dangerous waste without testing; however, there is a good chance that the waste—particularly scrap amalgam and pump filter sludge—do designate as dangerous waste. The LHWMP allows offices to test their amalgam wastes before disposal, or alternatively, to assume that the waste designates as dangerous waste and to handle it accordingly.

Another regulatory system affects dental amalgam discharges to the sewer. Wastewater treatment utilities like King County have limits (called 'local limits') for wastewater from businesses. King County's local limit for mercury is 0.2 parts per million (ppm) (or 200 ppb) for a grab sample and 0.1 ppm (or 100 ppb) for a daily average. Testing by King County Industrial Waste found a mean concentration of 150 ppm of mercury in wastewater from dental offices using amalgam, *almost three orders of magnitude above the discharge limit* (Metro, 1991). In order to reduce this, dentists would need to capture (filter or settle) mercury from the wastewater before discharging it.

2. Background of Dental Project, 1990-95

Mercury spikes in wastewater treatment system

Attention turned to dentists in the early 1990's, when the state Department of Ecology noted occasional high levels of mercury in the King County wastewater treatment system and required Metro, the wastewater treatment agency (now King County), to reduce discharges of mercury at the source. Because of their numbers, dentists were considered a potentially significant source of mercury, and a 1991 study confirmed that the dental sector was indeed a "significant and identifiable" source of mercury to the wastewater system. King County dentists accounted for an estimated 14 percent of mercury loading (Metro, 1991). (These findings have subsequently been corroborated in other municipalities (Chapman and McGroddy, nd; Rourke, 1993).

Source control in a dental office means settling or otherwise capturing mercury-bearing amalgam particles from wastewater before discharge to the sewer system. In the early 1990's, only a few amalgam separation units—manufactured in Europe—were available. Although many units could remove 95-99.9 percent of the mercury from wastewater, none could reliably enable a dental office to meet Metro's mercury discharge limit of 0.2 ppm (Metro, 1991).

During the period 1991-94, Metro reviewed available separation units for their effectiveness, developed a set of considerations by which to evaluate separation units, and published a hazardous waste guidebook for dentists. Metro maintained contact with vendors of equipment, the American Dental Association, the Washington State Dental Association, the Seattle-King County Dental Society and the University of Washington School of Dentistry with regard to this work.

1994 attempt to pass a 'rule' for dentists

In early 1994 Metro proposed a rule requiring dental offices to install amalgam separation equipment in order to control discharge of mercury-bearing amalgam. Although available equipment did not allow dentists to reliably meet the local discharge limit for mercury, the best available technology did remove 95-99.9 percent of the mercury from wastewater and was felt by the agency to be an acceptable solution.

During the public comment period Metro received more than a hundred letters, mostly negative. Dentists disputed the impact of dental amalgam on the environment and felt that amalgam separation equipment was untested, expensive and not readily available. The American Dental Association argued that amalgamated mercury found in dental amalgam did not pose an environmental risk and questioned the legality of the discharge limits as applied to dentists. There were threats of lawsuits. This was the second instance of a local jurisdiction applying regulatory controls on dental wastewater in the United States (Phoenix was the first), so its significance extended beyond the local arena. (In Europe, dental wastewater is regulated in a number of countries.)

Why the proposed rule was postponed

Instead of requiring dentists to install amalgam separation equipment, in 1995 Metro agreed to work with the dental community to meet mercury discharge limits voluntarily. An excerpt from Metro's Feb. 3, 1995 memo reads:

“ . . . the King County Department of Metropolitan Services (Metro) has decided to postpone promulgating the rule. Rather than establish the mechanisms required for regulatory compliance, Metro will promote voluntary compliance by continuing to work cooperatively with the dental community.

Many dental offices have already installed amalgam separation units and we expect this practice to continue without a formal regulatory requirement. We believe this decision is in our community's best interest because it is cost effective and protects our environment. If information contradicts this decision in the future, we will reconsider promulgation of a rule at that time.” (Grigsby, 1995)

One reason for postponing the rule was that amalgam separation equipment developed in Europe was just beginning to be available on the West Coast. It was relatively expensive, and the service infrastructure was undeveloped. Given more time, it was assumed that the supply of separation units would improve and that they would be cheaper, better serviced and more reliable.

In addition, dentists expressed interest in voluntarily controlling discharge of mercury if given time to do this. The University of Washington and several private dentists were testing separation units, and Metro assumed there was a commitment on the part of the greater dental community—if they weren't forced into compliance. From the regulator's perspective, the prospect of enforcing on more than 1500 dentists was daunting.

Another problem was differing views about the environmental fate of dental mercury. Based on its own study, the American Dental Association maintained that mercury in dental amalgam does not leach under TCLP testing (Fan, 1992). The Association argued that amalgamated mercury is not bioavailable and poses no environmental risk, and the ADA threatened to challenge mercury discharge limits as applied to dentists. This issue remains unsettled and is the object of ongoing research by the ADA and the Environmental Protection Agency.

In a March 14, 1995 letter to U.S. Representative Jim McDermott, Daryl Grigsby, Metro's Water Pollution Control Department director, offered these reasons for postponing the rule:

- mercury levels at treatment plants had markedly declined without a rule;
- the American Dental Association had acknowledged the importance of studying the fate of amalgam in wastewater and had begun its own studies;
- awareness of amalgam wastewater issues had risen dramatically in the dental community; and
- the cost of implementing the rule would outweigh environmental benefits (Grigsby, 1995).

The decision to postpone the rule and to work voluntarily with the dental community to install separation units promised a number of benefits. Metro was relieved of the burden of enforcing on 1500+ dentists. With time, the supply infrastructure would be able to develop, leading to lower

prices and better service. If allowed to make changes in an orderly manner, dentists could act on their expressed desire to control mercury discharges without unduly disrupting their operations.

Explicit in the rule postponement was the understanding that dentists would indeed buy and install amalgam separation units voluntarily. Metro assumed that a ‘critical mass’ of interested dentists—maybe 15 percent—would install separation units, and they could be used to motivate and educate others (Tomchick, 2000). However, because no real targets or timelines were spelled out, “success” remained unquantified.

To summarize what occurred during 1991-95: Metro was directed by Ecology to implement source controls of mercury discharges. Metro identified dentists as a “significant and identifiable” source of mercury to the wastewater system and proposed a rule requiring dentists to install separation units to capture mercury-bearing amalgam. Available units could capture 95-99% of the mercury in dental wastewater. Dentists objected to the rule on the grounds that separation equipment was not readily available, units were expensive and more time was needed in order to comply. In addition, organized dentistry argued that dental mercury posed no environmental risk. Metro agreed to postpone the rule and to work with the dental community on the voluntary installation of separation units.

The compromise solution promised a number of benefits. Metro was relieved of the burden of enforcing on 1500+ dentists. With time, the supply infrastructure would be able to develop, leading to lower prices and better service. If allowed to make changes in an orderly manner, dentists could act on their expressed desire to control mercury discharges without unduly disrupting their operations.

3. King County Dental Project, 1995-2000

In late 1995, the Seattle-King County Dental Society and the Local Hazardous Waste Management Program (LHWMP) began to collaborate on an outreach program for dentists regarding the management and disposal of hazardous wastes. Although precipitated by the need to increase the voluntary installation of amalgam separation units by dentists, the project eventually adjusted its focus to the voluntary collection and reclamation of scrap, trap, and pump filter amalgam wastes, as well as fixer, lead foils and chemiclave solution.

Dentists typically put amalgam wastes into the biomedical waste container (the 'red bag'), the garbage or down the drain. Reasons that dentists did not collect these wastes and reclaim them or handle them as 'hazardous' waste during the mid-1990's were:

- *Knowledge:* Dentists consider amalgam waste to be infectious waste and handle it the same as other infectious waste, e.g., put it into the 'red bag.' They don't know that wastes that designate as dangerous waste under state law need special handling and disposal.
- *Lack of service providers:* as of early 1997, no waste haulers in the Puget Sound area provided pick up services for metal-bearing dental wastes.
- *Habit:* after so many years of handling wastes a certain way, dentists wondered why their disposal methods were suddenly wrong.
- *Lack of awareness:* disposal of non-biomedical wastes was simply "not on the radar screen." There was little perceived environmental imperative.
- *Increased cost.* Reclamation of metal-bearing wastes, particularly mercury-bearing amalgam, inevitably costs more than putting it in the garbage or down the drain.

Reaching dentists

Compared to other business sectors, dentists are a highly organized professional group. Most (about 85 percent) belong to the Seattle-King County Dental Society, the Washington State Dental Association and the American Dental Association. These organizations allow information to flow down and out to members via publications, committees, workshops, legislative activities, officers and conferences.

A 1990 Metro survey of 427 randomly selected King County dentists (34 percent response rate) found that they prefer to receive waste management information in a brochure or manual (78%) or via newsletters and/or speakers (about 65% each). Less than half would use videos, consultations, seminars, trade fairs or information lines for this information. In addition, dentists appreciate well-substantiated, often technical information (Metro, 1991).

Reasons King County dentists cite for being willing to make changes in waste management practices include (in order of frequency): concern for the environment, availability of pick up services, having concise guidelines about what to do, concern for personal safety, economic advantage and concern about liability (Metro, 1991).

A 1997 study of dentists found that those who readily adopt new services were more likely to have dentist friends using the product or service. They were also more likely to enjoy

experimenting with new treatments (Fiset and Grembowski, 1997). A 1984 study found that Washington State dentists were more likely to use sealants if they had adopted other new technologies, if they had colleagues who used sealants, and if they rated themselves as willing to try new things. *The researcher concluded that new technologies can be promoted to dentists by first influencing opinion-leaders to try them out and model them for colleagues* (Chapko, 1991).

Like other business people, many in the dental establishment consider themselves over-regulated. Much of the attention focuses on Occupational Safety and Health Administration (OSHA) standards regarding infection control and AIDS prevention. A 1995 editorial titled "Dancing with regulators" in the *Journal of the American Dental Association* serves as a rallying cry for dentists to support "the ADA's efforts to temper government regulation with common sense. Practitioners are overwhelmed by the bureaucracy and excessive government regulations that direct every aspect of dentistry" (Meskin, 1995).

Outreach strategies

For almost five years (late 1995-summer 2000) the Seattle-King County Dental Society and King County's Hazardous Waste Management Program collaborated to educate dentists about the need to properly manage wastes and to remove infrastructure barriers (such as cost and lack of service providers). The overall goal was for dentists in King County to understand the importance of collecting and reclaiming hazardous wastes, for them to have the means to do this, and for them to commit themselves to doing it. The SKCDS and King County worked on a wide variety of fronts to accomplish these aims. Here is a chronology of project activities:

1996

- Formed project team
- Published 1st edition of poster and mailed to dental society members

1997

- Published 2nd edition of poster and mailed to dental society members
- Published hand-out on waste disposal service providers (pricing, phone, services, etc.)
- Recognized first EnviroStar dentists
- Worked with waste haulers to develop collection programs
- Made presentations to dental hygienists/assistants at voc tech programs and conferences
- Trained dental supply company staff re: waste issues

1998

- Published 3rd edition of poster and mailed to dental society members
- Published waste management guidebook for dentists
- Continued to: recognize EnviroStars dentists, work with private sector to develop disposal options, train hygienists and assistants, train supply company staff
- Published ads and articles in dental journals
- Published articles/photos in general news media
- Sponsored "Green Dentistry" session at NW Dental Conference
- Sponsored free waste pick up for dental wastes
- Promoted voucher incentive program (cash reimbursement for waste disposal)
- Dental society receives WIN environmental achievement award

1999

- Published 4th edition of poster and mailed to dental society members

- Published 2nd edition of waste management guidebook for dentists
- Continued to: recognize EnviroStars dentists, work with private sector to develop disposal options, train hygienists and assistants, train supply company staff
- Conducted 200+ site visits to dental offices
- Promoted voucher incentive program (cash reimbursement for waste disposal)

The following describes how the SKCDS and King County worked to improve knowledge about the issues, develop a new environmental ethic and remove infrastructure barriers.

Provide information: The SKCDS and King County developed a poster that succinctly told dentists how to manage each waste and who to call for recycling or disposal. The poster can be posted in a dental office along with OSHA-required posters. Five annual editions have been published and mailed to all members by the dental society. A companion guidebook called "Waste Management for King County Dentists" provides in depth explanations of legal requirements and contains a page flap for the poster. It was mailed by the society to all members and is now on the county website, where information is updated monthly. The poster won a "Golden Apple" award from a related professional association and the dental society won a WIN Environmental Achievement Award for producing these materials.

Create positive role models: The King County EnviroStar program recognizes businesses that take steps to be environmentally responsible. Proactive dentists were encouraged to become EnviroStars, and they in turn serve as role models for others. Newspaper articles, radio and bus board ads, phone book yellow-pages ads, and other events promoted these environmentally-responsible dentists to other dentists and to the general public. At the 1998 Pacific Northwest Dental Conference, two EnviroStar dentists presented a session on "Greening the Dental Office."

Develop more service providers: King County encouraged private companies to offer waste management services to dentists, and then worked with these firms and the dental society to promote the new services. The county and the dental society published a fact sheet outlining service providers and mailed it to all dental society members. They also promoted service providers via the poster, guidebook and website described above.

In 1999, the county, the dental society, and three hazardous waste service providers collaborated to provide a *free* waste pick up for dental offices. The county underwrote the pick up and disposal costs in an effort to jump-start a new behavior. The dental society promoted the project and screened applicants as a service to its members. And haulers allowed a special rate, hoping to attract long-term customers. The result was poor: only 15 dentists signed up for the program despite much promotion.

Mitigate costs: The county voucher incentive program provided matching funds to dental offices that contracted with waste management service providers, and a program jointly sponsored by the dental society and the county underwrote a special dental waste pick up using three new service providers (see above). Again, these programs helped introduce the dental community to service providers and paved the way for future use by offering cash rebates.

Conduct site visits (King County): Between fall 1999 and spring 2000, 221 dental offices received technical assistance visits from LHWMP field staff. Sixty-eight of the offices received another follow up visit. This exercise resulted in baseline data on the waste management practices of King County dentists as of spring 2000 and provided data on quantities of wastes properly and improperly disposed. It offered an opportunity for county staff to talk directly with large numbers of dental office personnel and sent the message that this issue is a priority for King County government.

4. Results

As of May 2000, five years after Metro (now King County) and the dental community agreed to work together on waste management issues, what is the situation? Are dangerous wastes being collected and reclaimed? Have offices installed amalgam separation units? Is there more awareness of the issue? Why, or why not?

The data in this chapter reflect the practices of dentists that have, for the most part, received information about waste management from mailers, articles or other dentists. Until late 1999, King County field staff didn't visit large numbers of dental offices. The effect of one-on-one contact is thus not explicitly called out in this report.

Waste disposal by dental offices

Table 1 shows the percentage of dental offices that properly dispose of the six key waste streams--scrap amalgam, chairside trap amalgam, pump filter amalgam, fixer, lead foil and chemiclave solution--for the period 1997-2000. "Properly dispose" means that the office collects and reclaims the waste or manages it as hazardous waste. (Only offices that generate a particular waste are included.) Offices that store a waste on-site or give it to a neighboring dentist aren't counted in the "properly dispose" total, even though they may not be illegally disposing either.

Waste disposal data were gathered through visits by King County field staff to dental offices. The number of visits varies from year to year. Some visits were by request while others were initiated by King County. From Sept 99 through April 2000, King County initiated 212 visits to dental offices, and these comprise a large portion of the data.

Except for fixer, it appears that the majority of King County dentists do *not* dispose of their hazardous wastes--including mercury-bearing wastes--using a permitted hazardous waste firm or recycler. Even scrap amalgam--which is clean, easy to collect, and easy to dispose of--is reclaimed by only about 40 percent of dental offices. The data don't appear to show any trends over time (though the measurement period is short.)

Table 1. Percentage of King County dentists that properly dispose of six key wastestreams, 1997- 2000*

	1997 Qtr 4	1998 Qtr 1-4	1999 Qtr 1-3	1999, Qtr 4 - 2000, Qtr 1
Scrap amalgam	n=14 36%	n=69 36%	n=69 51%	n=160 38%
Trap amalgam	n=14 21%	n=86 31%	78 18%	n=172 27%
Pump filter amalgam	no data	no data	no data	n=143 13%
Fixer	n=19 47%	n=97 61%	n=97 47%	n=201 61%
Lead foils	n=12 58%	n=87 44%	n=82 56%	n=184 41%
Chemiclave solution	n=13 0%	n=56 21%	n=47 9%	n=101 16%

* Based on data collected during field visits to King County dentists. Visits in 1999-2000 were by zip code. Visits during prior periods were either by zip code or by invitation of the dentist. Thus, earlier visits may be skewed toward more proactive dentists--those who invited field consultants into their offices.

Tables 2 and 3 provide more in depth data about the disposal of scrap amalgam and trap amalgam. These tables indicate that while the majority of dentists don't reclaim their waste amalgam, a significant number collect it and hold amalgam waste on-site, waiting to figure out what to do with it. Even so, about a quarter of the dental offices improperly dispose of scrap amalgam (put it down the drain, in the red bag or in the garbage), and half the offices improperly throw away amalgam collected in chairside traps.

Table 2. Disposal of scrap amalgam by King County dentists, 1997- 2000*

	1997 Qtr 4	1998 Qtr 1-4	1999 Qtr 1-4	1999, Qtr 4 - 2000, Qtr 1
No. visited**	14	69	69	160
	# / %	# / %	# / %	# / %
Properly dispose	5 / 36%	25/36%	35 / 51%	60 / 38%
Collected/not dispose	5 / 36%	29/ 42%	22 / 32%	57 / 36%
Improperly dispose	4 / 29%	15 / 22%	12 / 17%	43 / 27%

Table 3. Disposal of chairside trap amalgam by King County dentists, 1997- 2000*

	1997 Qtr 4	1998 Qtr 1-4	1999 Qtr 1-4	1999, Qtr 4 - 2000, Qtr 1
No. visited**	14	86	78	172
	# / %	# / %	# / %	# / %
Properly dispose	3 / 21%	27/ 31%	14 / 18%	46 / 27%
Collected/not dispose	3 / 21%	16/ 19%	7 / 9%	35/ 20%
Improperly dispose	8 / 57%	43/ 50%	57/ 73%	91/ 53%

For both tables:

* Based on data collected during field visits to King County dentists. Visits in 1999-2000 were by zip code. Visits during prior periods were either by zip code or by invitation of the dentist. Thus, earlier visits may be skewed toward more proactive dentists--those who invited field consultants into their offices.

**Only includes visits to offices that generate amalgam waste.

Options for waste disposal

Options have improved. More companies are now available to haul dental wastes. Whether this continues depends on if they are used.

Since 1996, three local waste management firms have stepped forward to offer waste pick-up services to dentists, and a national mail-away program for amalgam wastes advertises locally. Then in spring 2000, Stericycle, the only firm licensed to haul medical waste in King County, launched a program to pick up hazardous waste (as well as biomedical waste) from dentists -- essentially a "one-stop shopping" program.

Data obtained from private sector waste management firms suggests that the number of dentists interested in properly disposing of amalgam and fixer wastes is slowly growing. Table 4 shows the number of accounts each year for the period 1996 – 2000 for five private sector waste management firms that target dental offices. It's too soon to tell how the "one-stop" Stericycle program will be accepted.

Table 4. Private sector waste management firms—dental accounts

Type of firm	1996 & pre-'96	1997	1998	1999	2000 (to Apr)	Total
Local waste hauler, all wastes	0	0	1	20	4	25
National waste hauler, all wastes*	no data	no data	no data	no data	no data	nd*
National mail-away program, amalgam	no data	30	9	17	4	60
Local amalgam separation unit vendor – A	4	1	1	4	0	10
Local amalgam separation unit vendor – B	0	6	5	4	0	15

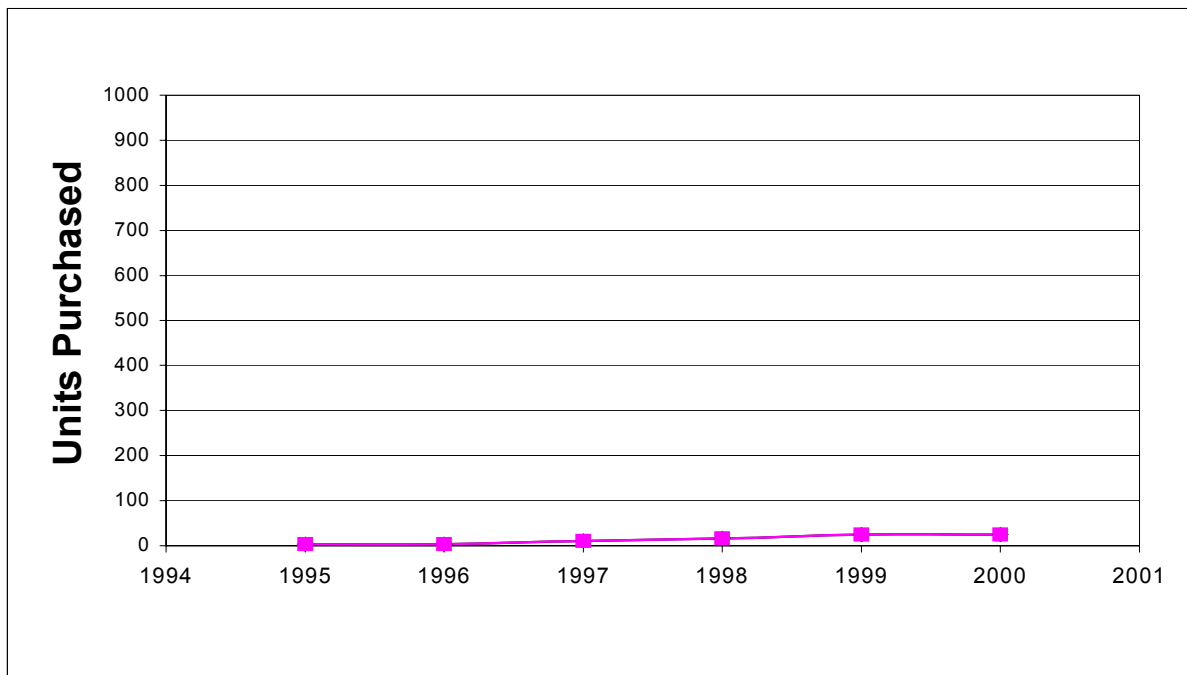
*No data provided by national firm. Anecdotal information from local sales representatives is that contracts with dental offices continue to grow. New staff have been added to handle this market. Company estimates 80-100 King County dentists dispose of wastes through them.

Number of separation units installed

In the early 1990's, no locally manufactured amalgam separation units were available in the Pacific Northwest. By spring 2000, three local companies were making and selling these units: R & D Services, Inc. in Seattle, Rebec in Edmonds, and Maxim Separation Systems in Victoria, British Columbia. In addition, Dental Recycling of North America, a New Jersey company, and Safety-Kleen, a national hazardous waste management firm, both offered wastewater filter systems to dentists in the Northwest.

Data on the numbers of amalgam separation units installed by King County dentists were provided by the firms that make and sell these units. Figure 1 shows the cumulative number of units installed since 1995, according to vendors of the equipment. As of March 2000, 25 units have been installed in King County dental offices.

Figure 1. Amalgam separation units installed by King County dentists



Twenty-five units represents 2-1/2 percent of the possible 1000 offices generating amalgam waste. Several offices with separation units didn't actually buy the units but were 'testing' them for the vendor.

Although no numerical targets for compliance were set in 1995, the low number of dental offices that installed amalgam separation units cannot signify success. This lack of interest in separation units is particularly significant inasmuch as the units are now sold and serviced locally and are relatively inexpensive (\$1000-2000). In addition, King County offers a \$500 rebate towards the purchase of a separation unit, further mitigating the barrier of cost.

So what accounts for the poor result? Here are some possible explanations:

- Withdrawing the rule may have left an impression that there was no longer any urgency about separation units.
- After 1995, King County turned its focus to the proper management of amalgam in chairside traps. This is a simpler process. Resources were thus directed away from separation units in the short-term.

- No certification process is available to verify that separation units would allow dentists to meet the legal requirements for wastewater discharge. Buying a unit didn't guarantee that a dental office would meet its legal obligation.
- Large-scale, voluntary changes involving basic information shifts and the purchase and installation of new equipment may realistically take longer than five years.
- Information about separation equipment was provided to dentists indirectly, not through on-site technical assistance visits.

Other results

Financial assistance

King County operates a cash reimbursement, or voucher, program to assist small businesses to reduce, properly manage or dispose of hazardous wastes. For dental offices, vouchers have been issued to reimburse offices for waste disposal costs and to offset purchase costs for waste reduction equipment like autoclaves and digital radiography. Since 1996, King County has issued a total of 264 vouchers to dental offices and paid \$34,957 toward hazardous waste disposal and reduction. This means that King County dentists themselves have also invested at least \$35,000 in hazardous waste management.

Table 5. Voucher reimbursements to King County dentists, 1996-Apr 2000.

Year of issue	Number of vouchers used	Cash value of vouchers used
1996		
1997	10	\$ 3,314
1998	84	\$13,876
1999	105	\$11,643
2000 (thru Apr)	65	\$ 6,124
Totals	264	\$34,957

Pilot free waste pick-up service

A collaborative project involving the SKCDS, King County and three private hazardous waste haulers aimed to increase the number of offices that established on-going contractual relationships with waste management firms. The county subsidized the cost of the first pick up, the dental society promoted the program and recruited participants, and the waste haulers tailored their programs to meet the particular needs of dental offices. The result of this effort was disappointing. Despite strong promotion and no cost, only 15 offices participated.

EnviroStars

By spring 2000, more than fifty dentists—including the dental society president, the president-elect and several members of the Executive Council--had become certified as EnviroStars (see Table 6).

Table 6. Number of EnviroStars dentists in King County

Year	Number of EnviroStars this year	Cumulative number of EnviroStars
1995	0	0
1996	2	2
1997	14	16
1998	28	44
1999	11	55
2000 (thru May)	3	58

5. Impact of dental wastes on the environment

Dental wastes designate as hazardous because of silver (in fixer), lead (in lead foils), mercury (in various amalgam wastes) and alcohol in chemiclave solution. Except for chemiclave solution, dental wastes are hazardous because they contain metals that are toxic and never go away (that is, never degrade) once they reach the environment. This section will focus only on the impact of mercury, since it has the most significant environmental implications.

Forty to fifty percent of amalgam material is mercury; the rest is a mix of silver, tin, and other metals (zinc, copper). Waste amalgam takes several forms: unused capsules that become dated; scrap that is left over when placing a filling or is carved out of the new filling; particles captured in a chairside sink filter or trap; sludge captured in a filter at the vacuum pump; and particles of amalgam suspended or dissolved in the wastewater going to the sewer or septic system. Many dentists also have old containers of elemental mercury in liquid form.

Data gathered by King County's Hazardous Waste Program in 1999-2000 indicate that 74 percent of King County dental offices—or 962 offices—generate scrap amalgam waste and that 81 percent—or 1053 offices—generate trap and pump filter waste. The same percentage (81 percent) discharges amalgam into the wastewater. The twenty percent that don't generate any amalgam waste include orthodontists, periodontists, pediatric dentists and others that don't place or remove amalgam fillings. (Note: waste quantities presented here are based on the assumption that the approximately 1600 dentists in King County translate into about 1300 separate offices.)

Disposing of amalgam: Where does it go when it's thrown away?

As noted in the preceding chapter, a minority of dentists properly manage scrap, chairside trap and pump filter amalgam waste. The percentages (based on site visits to 221 offices during 1999-2000) are 38%, 27% and 13% respectively. While a certain percentage of offices collect and hold the waste material while trying to figure out what to do with it, the others illegally put amalgam waste into the biomedical container (or 'red bag'), the garbage or down the drain.

Biomedical, or 'red bag,' waste. Dentists often put amalgam waste into the 'red bag' with other potentially infectious wastes because they consider it a "biohazardous" or "biomedical" waste. Thirteen percent put their scrap amalgam in the red bag, 28 percent put trap amalgam there, and 18 percent put amalgam from pump filters in the red bag. Currently, all red bag waste in King County is handled by one firm, Stericycle, which hauls the waste to its facility in Morton, Washington. Here the waste is shredded and heat-processed. The heat treatment process is likely to release elemental mercury from mercury compounds (Ruse, 2000). The treated waste is disposed in the hazardous waste landfill in Arlington, Oregon, although a portion of it (known as 'Sterifuel') can also be burned for fuel in facilities such as cement kilns, with further potential for release of mercury.

Sewered waste. Like other metals, mercury-bearing amalgam that enters the municipal wastewater system may end up in one of three places: precipitated in the plumbing or sewerage system; as post-treatment discharge to Puget Sound or local rivers; or in treated sewage sludge, called biosolids, that is land-applied on forests and farms (see next section).

Amalgam particles produced in dental procedures are moved by suction through the dental unit waste line. Sink filters with 0.7 millimeter (mm) mesh capture the larger particles, while particles that pass through sink filters move downstream. Because mercury and amalgam particles are dense, many will settle in the dental office vacuum lines and plumbing. Amalgam particles trapped in dental office plumbing and drainage pipes have been found to provide a continuing source of mercury to wastewater over time (Chapman and McGroddy, nd; Johnson, 1999).

The particles and dissolved mercury that don't precipitate in the pipes will enter the wastewater treatment system operated by King County or local jurisdictions. Most particles settle out in the sewage treatment process, into the biosolids. (There is some possibility that heavier particles separate out with other grit at the wastewater treatment plant and are sent to the landfill [Balogh, 2000]). Mercury concentrations in effluent from the county's two wastewater treatment plants are below the 'detect' level of 0.2 parts per billion (ppb) mercury and below the state permitted limits for mercury concentrations.

On the other hand, discharges from King County dental offices into the sewerage system don't meet King County's internal ("local") discharge limits. For mercury, these are 0.2 parts per million (ppm) (or 200 ppb) for a grab sample and 0.1 ppm or (100 ppb) for a daily average. Testing by King County Industrial Waste found a mean concentration of 150 ppm of mercury in wastewater from dental offices using amalgam, *almost three orders of magnitude above the discharge limit* (Metro, 1991). The 1991 study found that dental offices accounted for an estimated 14 percent of the mercury loading to the King County wastewater treatment system, or a conservatively estimated 51 pounds of mercury per year (Metro, 1991).

On-site wastewater systems. Dental offices in unsewered areas of the county discharge liquid wastes to an on-site septic tank/drain field system. The potential is high for mercury from these systems to enter local groundwater.

Biosolids. Treated sewage sludge, called biosolids, produced by the wastewater treatment process in King County is applied to forests and farmland as fertilizer. Mercury concentrations in biosolids from the two King County treatment plants were 2.51 mg/kg and 2.13 mg/kg in 1999, below the Environmental Protection Agency's "exceptional quality" criteria of 17 mg/kg mercury (King County, 1999).

Garbage. In King County, amalgam thrown into the garbage is buried in landfills, either in-state or outside the state. Although one environmental issue is the contamination of groundwater by landfill leachate, testing of groundwater monitoring wells near the Cedar Hills landfill in King County since 1986 has found no indication of leaching into groundwater (Jurgenson, 1999). The contribution of mercury from dental amalgams to landfill leachate is not known. In fact, little data are available on what happens to amalgamated mercury in the natural environment (Chapman and McGroddy, 1998).

Incinerated waste. None of King County's medical or municipal solid waste is directly incinerated. The two medical waste incinerators, Northwest Hospital and Veteran's Administration Hospital, closed operations in fall 1998, and municipal solid waste is not burned

here. Cement kilns such as the LaFarge plant in Seattle are permitted to burn shredded and sterilized medical waste, called Sterifuel, although this isn't currently happening (Trohimnovich, 2000).

Mercury from dental offices: How much?

One way to estimate the amount of mercury discharged to the environment by dental offices is to generalize from the 221 site visits done in 1999-2000. Data on the quantities of *scrap* amalgam improperly discharged were gathered during these visits and multiplied by .44, the percentage of the amalgam that is mercury. (It was not possible to estimate the amount of amalgam collected in the chairside traps and pump filters each month.) Extrapolating from these data to all dental offices, we estimate that King County dentists improperly discharge an estimated 151 lbs. of mercury in scrap amalgam each year. (See Table 7.)

Table 7. Mercury (Hg) improperly discharged in scrap amalgam annually by King County dental offices (Based on data from office visits during 1999-2000.)

	Sample offices n=221	All King Co. offices n=1300			
	<i>Per month (actual amt)</i>	<i>Per month (est. total*)</i>			<i>Per year (est. total)</i>
To 'red bag'	12 oz	71 oz	x 12	=	53 lbs
To garbage	13 oz	77 oz	x 12	=	58 lbs
Unknown site	9 oz	53 oz	x 12	=	40 lbs
Totals	34 oz	201 oz		=	151 lbs/Hg (per year)

* The 221 offices actually visited represent 1/6 of the offices that potentially produce amalgam waste in King County. The actual amount of mercury disposed by these dentists was multiplied by 5.8 to generate an estimate of mercury improperly disposed by all dentists.

Chairside traps and filters at the vacuum pumps also collect mercury-bearing amalgam particles. Fifty-three percent of King County dental offices improperly dispose of chairside traps (into the 'red bag,' the garbage or down the drain), and 56 percent improperly dispose of pump filter sludge. As noted above, the quantities of mercury contained in these traps and filters have not been measured.

With regard to the amount of mercury dissolved or suspended in wastewater leaving King County dental offices, a 1991 study found a mean 51 pounds of amalgam mercury going into the King County sewer system each year from dental offices (Metro, 1991). This estimate is considered conservative. What portion of this amalgam/mercury reaches the sewage treatment plants--rather than settling in the drain pipes--is unknown.

Table 8 presents a summary of our quantitative estimates and suggests that at least 200 lbs of mercury are discharged annually by King County dentists. This is an underestimate because it doesn't account for amalgam collected in sink traps, pump filters or drainage pipes.

This (conservative) estimate is corroborated by the 1991 Metro study which found that in addition to the 51 lbs of mercury per year discharged to the sewer by dentists, an estimated 130-150 lbs of mercury were discharged to the garbage. The 1991 study used self-reports from dentists regarding their disposal methods and used actual measurements of amalgams removed and placed to arrive at these estimates. (Metro, 1991). The limited progress by dental offices documented elsewhere in this report is not likely to significantly alter these estimates.

Table 8. Mercury (Hg) discharged from dental offices in King County, WA (total lbs per year) (estimated)

	Sewer	Red Bag	Garbage	Unknown	Total
Amalgam scrap	0	53	58	40	151
Trap amalgam	Unk.	Unk.	Unk.	Unk.	Unk.
Pump filter amalgam	Unk	Unk	Unk	Unk	Unk
Wastewater particles	51	0	0	0	51
Totals	51	53	58	40	201

Table is based on data gathered in 1999-2000 visits to 221 dental offices and on 1991 study (Local Hazardous Waste Management Program, 2000; Metro, 1991)

National data on mercury use by dentists. Nationally, the dental sector ranks third among users of mercury, purchasing about 40 tons a year, after the chlor-alkali industry (160 tons) and wiring (57 tons) (Swift, 1999). Although the quantity of mercury used doesn't necessarily correlate with the amount of waste produced (e.g., placing 40 tons of mercury in amalgam fillings doesn't mean that the same amount was removed from teeth), the relative importance of the user group is worth noting. In other words, dentists account for a significant portion of the mercury marketed in the United States. On the other hand, sales of mercury-silver amalgams to dentists have plunged in recent years because consumers prefer composite (plastic) fillings for cosmetic reasons (Brown, 2000).

Mercury pollution in King County and Washington State

The 1998 "List of Impaired and Threatened Waterbodies" (the 303(d) list under the Clean Water Act) found key King County water bodies/watersheds contaminated with mercury. These include Elliott Bay, the Duwamish Waterway and River, Central Puget Sound, the Green River and Mill Creek (Washington State Department of Ecology, 1998.) Elsewhere in Washington, mercury contaminates water and/or sediment in the Columbia River, Commencement Bay and Bellingham Bay (Washington Toxics Coalition, 2000). A 1998 U.S. Geological Survey found mercury to be much higher in sediments and sculpin (a bottomfish) in urban streams than in other streams in western Washington (Washington Toxics Coalition, 2000).

Fish and shellfish consumption advisories due to mercury contamination have been issued for all shellfish, bottom fish and crab in Eagle Harbor on Bainbridge Island; for walleye, whitefish and sturgeon on Lake Roosevelt in Eastern Washington; and for all shellfish, bottom fish, and crab in Sinclair Inlet (Washington State Department of Health, 2000).

Elsewhere in Puget Sound fish are under--but frequently approach--the 1.0 ppm Food Drug Administration limit for fish consumption (Perry, 2000).

Bioavailability of mercury in amalgam

Not all forms of mercury have the same impact on health and the environment. Methyl mercury compounds are extremely toxic and accumulate in muscle, thus moving through the aquatic food chain. Human beings are most commonly exposed to mercury by eating fish. Forms of mercury that are readily converted to methyl mercury thus pose greater environmental risk. The conditions under which mercury in dental amalgam can be converted to more toxic methyl mercury by bacteria in the environment are not well known (McGroddy and Chapman, nd).

It's well documented that incinerating dental amalgams releases mercury in a form that is readily methylated. The mercury is then dispersed by air. Heat treating amalgam may also release elemental mercury from mercury compounds (Ruse, 2000).

Studies of dental amalgam in aqueous solutions are less definitive. A recent review of the scientific literature finds that some studies show the release of elemental mercury from dental amalgam through corrosion (and elemental mercury is susceptible to methylation), while other studies suggest that very little of the mercury in dental amalgam may be soluble. Study data are highly variable and relate solubility of mercury in amalgams to a large number of variables—type of solution, type of amalgam, condition of amalgam surface, immersion time, particle size and formation of surface films. The authors conclude that much research is still needed on this question because “the specific mechanism by which mercury is released from amalgam particles has not been determined . . .” (McGroddy and Chapman, nd).

5. Conclusions and recommendations

There is mercury pollution in the Puget Sound region. Waters have been listed as contaminated under the Clean Water Act, mercury-contaminated sediments have been slated for clean up, and fish and shellfish consumption advisories have been issued for mercury. With regard to air emissions, there is a solid waste incinerator in Tacoma, the LaFarge cement kiln in Seattle is permitted to burn sterilized medical/dental waste, and Georgia Pacific in Bellingham discharges mercury into the air.

While mercury contamination of water and sediment is not as severe as is found in other parts of the country (e.g., the Great Lakes, San Francisco Bay, and Massachusetts Bay), and except for Georgia Pacific and the Tacoma incinerator, there are few large point sources, the Washington State Department of Ecology has identified mercury as one of the priority pollutants on its list of persistent, bioaccumulative and toxic chemicals (Department of Ecology, 2000). The state has called for the virtual elimination of mercury and will be developing strategies to accomplish this. (Department of Ecology, 1999).

Dentists are a focus because they account for a significant portion--an estimated 14 percent--of the mercury entering King County's wastewater treatment system. In the United States, dentists are the third largest users of mercury, buying 40 tons a year. And metal-bearing wastes--including amalgam wastes--from dental offices are relatively easy to capture and reclaim.

The fate of amalgamated mercury in solution (both saline and freshwater) is still not well understood. In addition, the contribution of amalgamated mercury to mercury found in biosolids-amended soils hasn't been studied. What can be said about the question of whether or not amalgamated mercury is available to the environment is that the mechanisms by which mercury is released from amalgam particles are not known and are the subject of continuing research.

What *is* known is that a significant percentage of King County dentists continue to throw away amalgam waste. Twenty-seven percent put scrap amalgam into the red bag, garbage or down the drain, even though there are now viable alternatives for reclaiming it. More than half improperly dispose of amalgam collected in chairside traps and vacuum pump filters. Very few offices have installed separation units to filter particles from wastewater. Failure to capture amalgam wastes results in the improper disposal of a conservatively estimated 200 pounds of mercury each year in King County alone. Capturing this mercury is relatively easy and inexpensive.

Other metal-bearing wastes, such as silver in fixer and lead in lead foils, are also thrown away, though in lesser quantities. Fourteen percent of King County dental offices throw away lead foils and 26 percent put untreated fixer down the drain.

After five years of aggressive outreach on the part of the SKCDS and King County, results are mixed and not overwhelming. In 1995 the King County dental community committed to taking steps towards capturing and properly reclaiming amalgam wastes. Since then the dental society and King County have put time and financial resources into educating dentists on this issue and improving the waste management infrastructure. Activities include publication of posters,

handbooks, brochures, websites and ads; cash incentives; recognition and promotion via EnviroStars designation; training dental assistants and hygienists; and visits to more than 400 offices. The result of all of this outreach is that 25 offices have purchased amalgam separation units and less than forty percent collect and reclaim other mercury-bearing wastes.

This situation raises several issues that are of direct concern to the dental community:

1. Today the options for disposing of hazardous dental wastes are significantly better than three years ago. Whether or not the new services continue to be available depends on their use. Competition for markets creates better services and lower prices: if no one uses waste management services, they will go away. Does the dental community want to see these services continue, and if so, what can be done to ensure this?
2. A growing number of dental offices have taken steps to properly capture and reclaim their metal-bearing waste. Some have spent significant funds to set up proper management systems. This creates the issue of an un-level playing field: how do those offices that spend money to 'do the right thing' have any advantage over those that ignore legal requirements? Is it time to regulate dental offices that haven't voluntarily complied with the most basic requirements? Should the dental community police itself? What is the dental community's perspective on the fact that there are very different levels of compliance among dental offices?
3. Very few offices (25 out of a potential of more than 1000) have voluntarily installed amalgam separation equipment even though prices have gone down, local units are available, and quality is good. After the proposed rule was set aside in 1995, the understanding was that dental offices would voluntarily install this equipment if given time. This isn't the case. Why? What are the barriers to this? Is voluntary movement on this issue even possible?
4. Given that five years ago the special management of metal-bearing dental wastes was a new issue to most dentists, how do we evaluate progress to date? Is five years enough time to enlist a widespread change in practices on a new issue? Is ten years more realistic? Or have those who will change--voluntarily--already done it? What are the barriers for the others?

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